KEEP WITHIN YOUR LIMITS

James R. Lowery, Baker Hughes, USA, considers how best to reduce emissions leaked from control valves, in order to better comply with industry standards and requirements.

Throttling valves used for process control are largely identified as a leading source of carbon emissions, contributing up to 60% of total emissions within gas fields, pipelines and hydrocarbon processing facilities. Dynamic operation of control valves and continuous movement of components accelerate internal wear, which eventually leads to the exposure of small leak paths to atmosphere. If left unattended, these leak paths can


COVER STORY
50

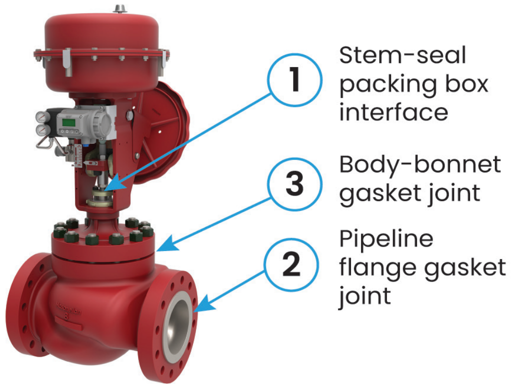

Figure 1. Reciprocating valve.

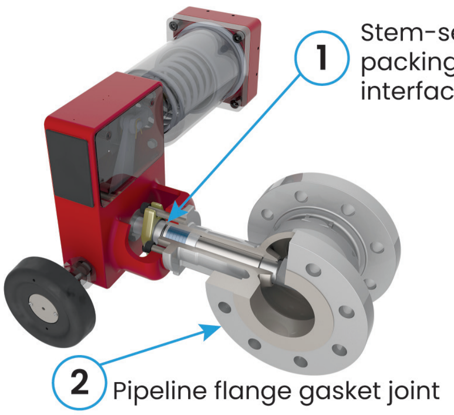

Figure 2. Rotary valve.

become a major source of fugitive emissions. On top of the challenges of dynamic operation, LNG applications introduce thermal cycling of temperature that also must be considered, as rapid temperature excursions and material expansions/contractions can also be a major source of increased emissions. In attempt to stay ahead of government regulations, many end-users self-impose stricter internal codes to provide a healthier and safer workplace for both employees and the environment. The conservative approach is often a great step forward towards environmental stewardship and overall plant efficiency. However, if not specified correctly, long-term benefits may not be realised as over-specification can lead to misapplied product for the application. This article will outline several factors to consider for control valve specification, including design attributes to reduce and eliminate potential leaks, such as suitable construction and testing requirements for the application where they are to be used.

Valve selection and design considerations

In order to reduce emissions through a control valve, it is important to understand potential sources of leakage for appropriate valve selection. For a typical control valve, there are three common sources of potential leakage. Figures 1 and 2 break down the following areas found in both reciprocating and rotary control valves:

- Stem-seal packing box interface.
- Pipeline flange gasket joint.
- Body-bonnet gasket joint.

Both reciprocating globe style and rotary style control valves will find the pipe flange gasket joints and the stem-seal packing box interface as potential paths for process fluid leakage into the environment. However, many rotary style control valves include a unique and distinct advantage of an integral body-to-bonnet one-piece connection, thus eliminating that entire location as a leak path. Another advantage of rotary control valves in managing fugitive emissions is the rotating motion of the valve stem as the valve is throttled open and closed. The stem and seal physically stay within the packing area, minimising the possibility of introducing foreign particles or debris into the sealing interface. As a result, these valves are more effective in reducing the possibility of fugitive emissions leakage, and normally deliver greater reliability and operating efficiency from this perspective. For applications that desire ultra-low leakage, rotary valves will offer a distinct advantage and should be considered for specification wherever possible.

In addition to control valve specifications, plant users should follow similar processes to valve suppliers when it comes to preparing the gasket surfaces within their associated piping. This includes providing piping guidelines for design and installation with attention to detail, including the following:

- Machining appropriate roughness and serrations of the gasket joint surfaces.
- Applying appropriate torque and assembling with the proper sequence to tighten down the bolts.
- Proper centring of the gasket as it resides against the seals on the mating surfaces.

Low-emission packing

Unlike isolation valves, control valves have a significantly higher number of operating cycles per day. These valves continuously throttle to maintain process variables, e.g. pressure, temperature and flow rate. Due to frequent movement of the stem inside the packing box, control valve seals wear at a much quicker pace. This means, the steam-seal packing box interface is at higher risk of leakage as compared to previously mentioned static gasket joints and should be monitored and maintained whenever possible. Figure 3 shows the differences in the packing box design of reciprocating globe and rotary control valves. The linear throttling motion of a reciprocating globe valve requires a more complex design, in order to maintain the packing during operation and to avoid the introduction of foreign debris as the stem is moved in and out of the packing box area. Fewer components and simplicity is another major advantage for the rotary valve (Figure 4). For cryogenic LNG applications, an extended bonnet is often required to extend the soft goods away from the cryogenic conditions. Figure 5 shows an example of how an extended bonnet moves the packing box up and away from the process fluid. This option is available on both reciprocating globe and rotary style control valves as the design philosophies

Table 1. Summary of emissions specifications and requirements

	Application	Mechanical cycles	Thermal cycles	Pressure	Fluid	Method	Packing leak rate
ISO-15848	Control and on-off valves	Control valves: CC1 (20 000 cycles) CC2 (60 000 cycles) CC3 (100 000 cycles) On-off valves: CO1 (205 cycles) CO2 (1500 cycles) CO3 (2500 cycles)	Control valves: CC1 (2 cycles) CC2 (3 cycles) CC3 (4 cycles) On-off valves: CO1 (2 cycles) CO2 (3 cycles) CO3 (4 cycles)	Mfg. defined	Helium	Isolated vacuum atmosphere	A: $1{,}78\ 10^{-7}$ B: $1{,}78\ 10^{-6}$ C: $1{,}78\ 10^{-4}$ UOM mbar. L/s per mm stem dia
					Methane	Sniffing	A: ≤ 50 B: ≤ 100 C: ≤ 500 UOM ppmv of methane
ANSI / FCI 91-1	Control valves	A (100 000 cycles) B (25 000 cycles) C (100 000 cycles) D (25 000 cycles) E (5000 cycles)	A (3 cycles) B (3 cycles) C (0 cycles) D (0 cycles) E (1 cycle)	Mfg. defined	Methane	Sniffing	CL 1: 100 ppm CL 2: 500 ppm
API 622	On-off valves	1510	5	600 psi (41.4 bar)	Methane	Sniffing	500 ppmv
API 624	On-off valves	310	3	600 psi (41.4 bar)	Methane	Sniffing	100 ppmv
VDI 2440	Not defined	Not defined (typ. 500 – 2000)	Not defined	Not defined (typ. 40 bar)	Helium	Isolated vacuum atmosphere	T≤250°C : 10^{-4} T≥250°C : 10^{-2} UOM mbar . L / (s . m)

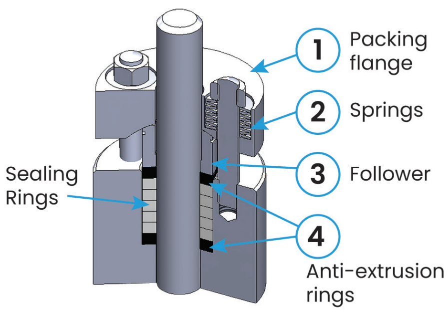

Figure 3. Reciprocating valve packing design.

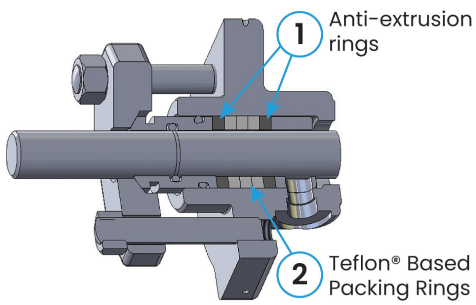

Figure 4. Rotary valve packing design.

are the same. This also allows for proper insulation if warranted by the environment where the control valve may be installed.

Fugitive emissions requirements

Fugitive emissions requirement are governed by various regulatory bodies and differ by region. In Europe, ISO 15848-1 is the most commonly accepted test standard for low emission valves, whereas the American Petroleum Institute (API) standards are most commonly specified in North America. However, it is important to understand that many of the API specifications, such as API-622, API-624 and API-641, were written and intended for isolation valves and may not properly address the required mechanical cycles demanded for a control valve application. These specifications commonly call for mechanical cycles in the range of 310 – 1510, and thermal cycles in the range of 3 – 5. Table 1 summarises the test criteria for each of the common test standards mentioned within the industry today.

Environmental Protection Agency requirements

The US government controlled Environmental Protection Agency (EPA) has set fugitive emissions limits to be met by the industry. The general limit in existence today is not to exceed 500 ppm. Continuous industry discussions are considering pushing these limits lower from 500 ppm to 100 ppm, which correlate to several of the consent decrees that are under enforcement today. The direction of regulatory agencies is to tighten up the allowable leakage and utilise the latest technology available. While specifying the use of the latest technology, certified low leak technology (CLLT) is another approach for consideration. CLLT is general terminology used by the EPA which covers requirement for both 'low-E packing' and 'low-E valve'. EPA's consent decree provide definitions for these terminologies as follows:

- 'Low-emissions packing' or 'low-E packing' shall mean:

Table 2. Target temperature classes

Low temperature	High temperature
-196°C (-320°F)	Room temperature
-46°C (-50°F)	Room temperature
-29°C (-20°F)	Room temperature
Room temperature	200°C (392°F)
Room temperature	400°C (752°F)

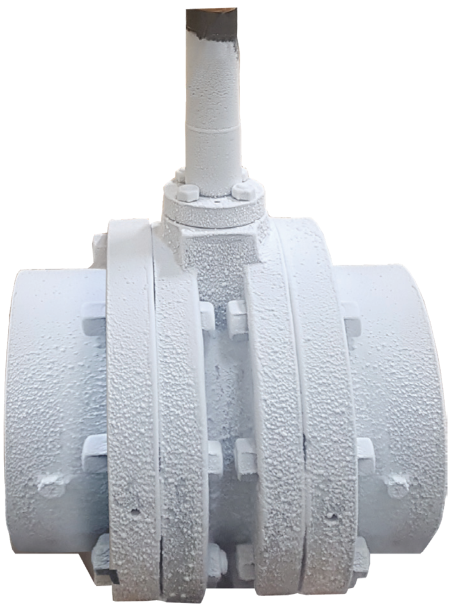

Figure 5. Valve with extension bonnet.

- A valve packing product, independent of any specific valve, that has been tested by the manufacturer or a qualified testing firm pursuant to generally-accepted good engineering practices for testing fugitive emissions, and that, during the test, at no time leaked at greater than 500 ppm, and, on average, leaked at less than 100 ppm.
- 'Low-emissions valve' or 'low-E valve' shall mean:
  - A valve (including its specific packing assembly) that: (1) has been tested by the manufacturer or a qualified testing firm pursuant to generally-accepted good engineering practices for testing fugitive emissions and that, during the test, at no time leaked at greater than 500 ppm, and, on average, leaked at less than 100 ppm; or (2) is an extension of another valve that qualified as 'Low-E' (under point 1).

A company can take a forward looking approach and set their own limit. ISO 15848-1 shows a leakage class as low as 50 ppm, which can be achieved by many leading suppliers today. Knowing the limits and best available technology on the market today are all important elements. The last thing to consider prior to writing the valve specification would be testing temperatures.

Low temperature considerations

The actual operating temperature of the application should be taken into consideration as part of production qualification testing. As discussed, the difference in mechanical and thermal cycles can vary from standard to standard, as can the temperature at which a test is qualified. The ISO 15848-1 outlines a series of ranges as recommended target test temperatures (Table 2).

While the fluid temperature is measured in the flow path, the packing and body temperatures are recorded for informational purposes. Running a test through similar conditions is important to ensure the valve will perform under the loads within the actual application. A valve manufacture could qualify the valve for cryogenic applications, yet never officially test at the extreme low temperatures, resulting in a packing design that is not truly fit or qualified for the application.

Creating a sustainable plan

There are many methods to measure, monitor and address fugitive emissions today. The most common are leak detection and repair (LDAR) agencies that provide a contractual service. While that is a common practice for mechanical equipment, such as pumps and isolation valves, control valves offer another in-situ method: smart positioners. Digital positioners have become common place in the industry over the last 20 years. This is a powerful tool that allows the user to continuously monitor the health of the valve. If certain variables are monitored over time, the user can set alarms to identify problems, such as emissions leakage, well in advance of an actual detectable event. This is the single biggest technology advantage control valves offer in reducing fugitive emissions today.

Conclusion

When it comes time to specify the next control valve, a large leap can be taken if the following items are taken into consideration:

- Does the packing solution offer 'certified low-leak technology' compliance and certificates?
- What leakage tightness is required by the application?
- Is the qualification test completed at cryogenic temperatures?
- How many mechanical and thermal cycles has it been qualified under?
- Has an independent third-party verified the testing?
- Has consideration of implementing a sustainable plan to monitor factors such as friction on the valve stem and early emissions detection utilising a smart positioner?

The answers to these questions can facilitate a step forward, by helping to build confidence to reduce fugitive emissions on the next control valve specification. LNG